NPOESS Preparatory Project
New Products for Research and Operations

In the next decade, weather forecasters, climate researchers, and decision-makers will rely on the National Polar-orbiting Operational Environmental Satellite System (NPOESS) to meet many of their needs for remotely-sensed, Earth science data and information. NPOESS will replace the heritage National Oceanic and Atmospheric Administration (NOAA) Polar-orbiting Operational Environmental Satellites (POES) and Department of Defense (DoD) Defense Meteorological Satellite Program (DMSP) spacecraft with a single operational satellite system to provide global environmental observations. NPOESS builds on research and technology development by the National Aeronautics and Space Administration (NASA) demonstrated through their Earth Observing System (EOS) missions.

To ensure a successful transition from current research to future operations, the tri-agency NPOESS Integrated Program Office (IPO) and NASA are partners in the NPOESS Preparatory Project (NPP) that is scheduled for launch in 2010 as a precursor to NPOESS. NPP will accomplish two key objectives: (1) reduce final development risks for NPOESS by providing on-orbit testing, calibration, and validation of sensors, algorithms, and ground-based operations and data processing systems prior to the launch of NPOESS-C1 in 2013; and (2) provide continuity of calibrated, validated, and geo-located NASA EOS Terra, Aqua, and Aura global imaging and sounding observations. NPP will test the on-orbit performance of the primary NPOESS sensors, and will validate the ground system design for receiving, processing, and distributing data and products. NOAA, DoD, and NASA will have real-time access to data from NPP for use and critical evaluation, ensuring that NPOESS products will be incorporated into operations soon after launch.

NPP will be launched into an afternoon, sun-synchronous polar-orbit (1330 local time ascending node) to reduce the risk of a data gap between the last POES (NOAA-N') and the first NPOESS spacecraft. The satellite will be commanded from the NPOESS Mission Management Center at NOAA's Satellite Operations Facility (NSOF) through a ground station located at Svalbard, Norway. Svalbard is located at high enough latitude (78 degrees north) to be able to "see" and downlink data from all 14 daily NPP satellite passes, so there will be no "blind" orbits as currently occurs with POES. The global stored mission data from NPP will be transmitted from Svalbard within minutes to the U.S. via a fiber-optic cable system that was completed in January 2004 as a joint venture between the IPO, NASA, and the Norwegian Space Center (NSC). The Svalbard ground station and fiber-optic link will improve data latency (time from observation by the satellite to availability of processed data) from NPP compared to the ~120-180 minute data latency from POES and DMSP. When NPOESS-C1 launches in 2013, stored mission data will be transmitted to a globally distributed network of ground stations termed SafetyNet™ that will deliver 95% of the processed data within 28 minutes from the time of on-orbit collection. This dramatic, four-to-five fold improvement in data latency from NPOESS will lead to significant improvements in forecasts produced by numerical weather prediction (NWP) models by delivering data updates much earlier and more frequently than provided by today's satellites.

The spacecraft instruments are designed for autonomous operations for up to 60 days without commanding from the ground. On-board data handling capabilities will be sufficient to store data at instrument resolution globally, so there will be no need to schedule special higher-resolution imagery products (i.e., as currently occurs with POES Local Area Coverage-LAC and DMSP Fine Mode). NPP will generate approximately 1.5 terabytes of data per day that will be processed into about 25 separate Environmental Data Records (EDRs) and higher level products at the NSOF and the Air Force Weather Agency (AFWA).

NPP will also support real-time Direct Broadcast (DB) services via an X-band downlink. There are currently over 150 ground stations worldwide that are being used to acquire real-time, DB data (i.e., imagery) from the X-band downlinks on NASA'a EOS Terra and Aqua satellites. These users will be able to receive real-time data from NPP after it launches in 2010 by using the International Polar Orbiter Processing Package (IPOPP) that is being developed by the IPO through a collaborative arrangement with the Direct Readout Laboratory at NASA's Goddard Space Flight Center and the Cooperative Institute for Meteorological Satellite Studies at the University of Wisconsin-Madison.

NPP will carry the following advanced imaging and sounding instruments: Visible/Infrared Imager Radiometer Suite (VIIRS); Cross-track Infrared Sounder (CrIS); Advanced Technology Microwave Sounder (ATMS); Ozone Mapping and Profiler Suite (OMPS); and Clouds and the Earth's Radiant Energy System (CERES). With these instruments, NPP will demonstrate the utility of improved imaging and sounding data in short-term weather "nowcasting" and forecasting and in other oceanic and terrestrial applications.

The 22-channel VIIRS will collect calibrated visible/infrared radiances to produce about 20 different EDRs including imagery, cloud and aerosol properties, albedo, land surface type, vegetation index, ocean color, and land and sea surface temperature to fulfill functions similar to what the Moderate Resolution Imaging Spectroradiometer (MODIS) does for NASA's EOS Terra and Aqua missions. VIIRS will provide complete daily global coverage over the visible, short/medium-infrared, and long-wave infrared spectrum at horizontal spatial resolutions of 370 m and 740 m at nadir. VIIRS will image at a near constant horizontal resolution across its ~3000 km swath (i.e., from 370 m at nadir to ~800 m at edge of scan) a significant improvement over NOAA's Advanced Very High Resolution Radiometer (AVHRR) and NASA's MODIS instruments. VIIRS also has a day/night band to detect low levels of visible-near infrared radiance at night from sources on or near the Earth's surface, such as low clouds and fog illuminated by moonlight, snow cover, and lightning flashes. VIIRS will produce low-light imagery at a higher horizontal resolution than the Operational Linescan System (OLS) on DMSP that also has this capability.

The Cross-track Infrared Sounder (CrIS) and the Advanced Technology Microwave Sounder (ATMS) on NPP will provide vertical profiles of atmospheric temperature, humidity, and pressure from the surface to the top of the atmosphere. CrIS senses upwelled infrared radiances from 3 to 16 µm at very high spectral resolution (~1300 spectral channels) to determine the vertical atmospheric distribution of temperature and moisture from the surface to the top of the atmosphere across a swath width of 2200 km. CrIS will succeed the Atmospheric Infrared Sounder (AIRS) which is on NASA's EOS Aqua spacecraft and fly in a complementary orbit with the Infrared Atmospheric Sounding Interferometer (IASI) on the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) Meteorological Operational (Metop) satellites. ATMS has 22 microwave channels in the 23-183 GHz range to provide vertical temperature and moisture soundings. Data from CrIS and ATMS will be used to construct atmospheric temperature profiles at 1° K accuracy for 1 km layers and moisture profiles accurate to 15 percent for 2 km layers to approximate the accuracy of data obtained from radiosondes.

The Ozone Mapping and Profiler Suite (OMPS) will use nadir and limb scanning ultraviolet (UV) instruments to collect atmospheric total column and vertical profile ozone data and continue the daily global data produced by the current ozone monitoring systems, the Solar Backscatter Ultraviolet radiometer (SBUV)/2 and Total Ozone Mapping Spectrometer (TOMS), but with higher fidelity. The OMPS limb scanner is expected to provide vertical profiles of ozone concentrations for 3 to 5 km thicknesses of the atmosphere as compared to the 7 to 10 km thicknesses obtained from the SBUV/2 on NOAA POES.

The Cloud and Earth Radiant Energy System (CERES) instrument consists of three broadband radiometers, covering the spectral regions from 0.3 to > 50 µm, which scan the Earth from limb to limb. CERES will provide measurements of the space and time distribution of the Earth's Radiation Budget (ERB) components. CERES will continue a nearly 30-year record of measurements of the Earth radiation budget by instruments on NASA spacecraft. Data from CERES will be used in conjunction with VIIRS to study changes in the Earth's energy balance and key changes in clouds and aerosols to determine the effect of changing clouds on the Earth's energy balance from space. It is this balance between the incoming energy from the Sun and outgoing energy back to space that determines Earth's temperature and climate.

The visible and near infrared channels on VIIRS will be used to generate high resolution cloud imagery, ocean color, sea ice, aerosols, vegetation, and land surface type products. The short- to long-wave infrared channels will provide data to derive cloud properties (cloud type, cloud particle size, cloud top height, cloud top temperature), snow cover, sea surface temperature, and fires. Multi-channel algorithms will combine visible and infrared data to generate measurements such as albedo that is important in measuring and understanding the Earth's energy balance. These multi-spectral capabilities will allow users to accurately detect phenomena such as volcanic ash plumes and discriminate low clouds from fog that may significantly impact aircraft operations.

Current users of the multi-spectral features on MODIS are paving the way for VIIRS. The U.S. Naval Research Laboratory (NRL) in Monterey, California pioneered multi-spectral techniques for MODIS in support of military operations in the Middle East and Southwest Asia. NRL, Fleet Numerical Meteorology and Oceanography Center (FNMOC), and AFWA are currently using real-time multi-spectral images from MODIS to monitor and predict dust storms, map low clouds at night, and derive other operational products. For example, Figure 1a is a MODIS true color image of fires in southern California. Multi-spectral enhancements of the same image reveal areas of dust plumes caused by strong Santa Ana winds rather than smoke from wildland fires, as shown in Figure 1b. These techniques will be transitioned to VIIRS that will have imaging capabilities very similar to MODIS. Figure 2 is a nighttime image created as a composite from DMSP OLS and Geostationary Operational Environmental Satellite (GOES) infrared imagery that allows a forecaster to discriminate among low clouds, high clouds, and snow cover at night. With VIIRS, this type of operational product will be produced from a single instrument. The high spatial resolution, large swath, and accuracy of VIIRS will provide current operational users with new opportunities in the NPP/NPOESS era.

Higher (spatial, temporal, and spectral) resolution and more accurate sounding data from CrIS and ATMS will support continuing advances in data assimilation systems and NWP models to improve short- to medium-range weather forecasts. Assimilation of high-spectral resolution radiance data from AIRS into NWP models at NOAA's National Centers for Environmental Prediction (NCEP) has already resulted in a several hour increase in forecast skill/range at five to six days in both northern and southern hemispheres, a significant improvement that normally takes several years to accomplish. CrIS will produce operational sounding data comparable to AIRS. VIIRS will deliver high resolution, radiometrically accurate data on surface albedo, land surface type, sea surface temperature, snow cover, and ice extent for ingesting into global and regional models. OMPS will profile ozone vertically in 3 km layers to provide better specification of stratospheric ozone that is now being used as a tracer in global NWP models.

High resolution, multi-spectral instruments on NPP and NPOESS will provide image and sounding products useful to the forecaster that aren't available from geostationary satellites. NASA's Short-term Prediction Research and Transition (SPoRT) Center has been demonstrating the utility of higher resolution measurements from polar-orbiting satellites by providing real-time data and products from NASA's MODIS and AIRS instruments to National Weather Service (NWS) forecasters on an experimental basis to improve short-term weather forecasts. NPP will maintain continuity of high-resolution data from NASA's EOS missions during the transition to NPOESS. NPP data will be available in a timeframe consistent with the projected installation of the next generation Advanced Weather Information Processing System (AWIPS) at NWS forecast offices.

Even as data from NASA's MODIS and AIRS instruments are being used to support current operations, we are preparing weather forecasters and other users of remote sensing data to exploit NPP and NPOESS data as soon as these new systems launch. Over the past six years, the Cooperative Program for Operational Meteorology, Education and Training (COMET) has focused its satellite training on the capabilities, applications, and relevance of NPP and NPOESS to operational weather forecasters and other user communities. The goal is to stimulate greater use of current and future satellite observations and products in operational weather forecasting. COMET has developed and published over 20 training modules on topics such as: Imaging with NPOESS VIIRS - A Convergence of Technologies and Experience; Microwave Remote Sensing – Overview; Multi-spectral Satellite Applications - Monitoring the Wildland Fire Cycle; The SPoRT Center - Infusing NASA Technology into NWS WFOs; and NexSat: Preparing Users for the NPOESS/VIIRS Era. A complementary training effort is hosted by NRL Monterey on their NRL/NPOESS Next Generation Weather Satellite Demonstration Project (NexSat) website. NexSat uses real-time imagery from current operational (e.g, POES and DMSP) and research (e.g., NASA's EOS Terra and Aqua) satellites to highlight the expected capabilities of comparable sensors on the future NPP and NPOESS. The common goal of the COMET, NRL/NexSat, and SPoRT Center efforts is to ensure that forecasters and other users will be prepared to use data and products from NPP and NPOESS on Day 1 of operations.

The following articles are excellent sources of information on expected VIIRS imagery capabilities and NPOESS on-line satellite training. These articles are available on-line:

Lee, T.E., S.D. Miller, F.J. Turk, C. Schueler, R. Julian, S. Deyo, P. Dills, and S. Wang, 2006: The NPOESS VIIRS Day/Night Visible Sensor. Bull. Amer. Meteor. Soc., 87, 191-199.
http://ams.allenpress.com/archive/1520-0477/87/2/pdf/i1520-0477-87-2-191.pdf

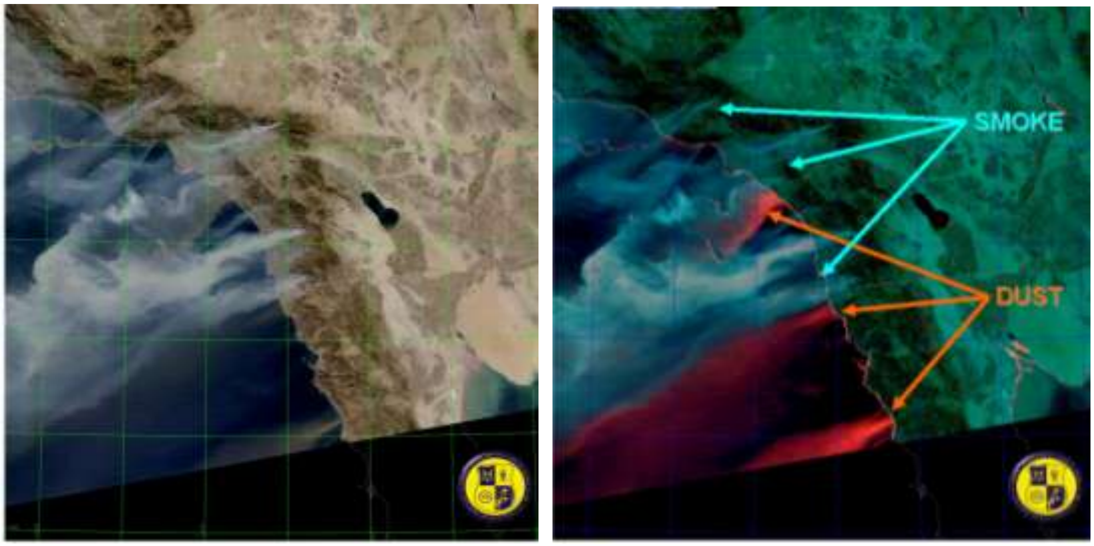
Miller, S.D., J.D. Hawkins, J. Kent, F.J. Turk, T.F. Lee, A.P. Kuciauskas, K. Richardson, R. Wade, and C. Hoffman, 2006: NexSat: Previewing NPOESS/VIIRS Imagery Capabilities. Bull. Amer. Meteor. Soc., 87, 433-446.
http://ams.allenpress.com/archive/1520-0477/87/4/pdf/i1520-0477-87-4-433.pdf

Lee, T.F., S.D. Miller, F.J. Turk, J.D. Hawkins, S. Wang, P. Dills, C. Hoffman, G. McWilliams, G. Mineart, and Z. Jelenak, 2007: NPOESS Online Satellite Training for Users. Bull. Amer. Meteor. Soc., 88, 13-16.
http://ams.allenpress.com/archive/1520-0477/88/1/pdf/i1520-0477-88-1-13.pdf

Additional information on NPP, NPOESS, and training is available at the following websites:

NPP and NPOESS:	http://www.npoess.noaa.gov/
	http://jointmission.gsfc.nasa.gov/
COMET/NPOESS:	http://www.meted.ucar.edu/npoess.php
NRL/NexSat:	http://www.nrlmry.navy.mil/NEXSAT.html
SPoRT Center:	http://www.ghcc.msfc.nasa.gov/sport/
NWA Remote Sensing Committee:	http://www.nwas.org/committees/rs/

Craig Nelson and Tom Lee, Remote Sensing Committee



(a) (b)

Figure 1. MODIS true color image of southern California taken on 23 October 2007. (a) Huge outbreaks of what appears to be smoke (bluish white) from southern California fires. (b) The dust enhancement applied to the same image shows that some of what looked like smoke is really dust (red) picked up by strong Santa Ana winds and blown offshore.

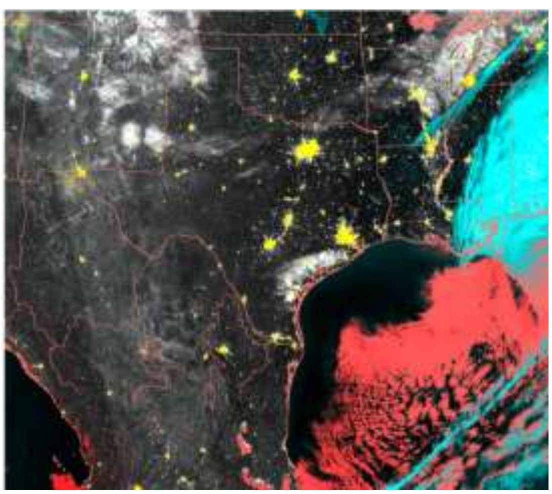


Figure 2. Snow cover over south Texas from a storm that occurred on Christmas Eve 2004. This product is a nighttime image constructed for 25 December 2004 that was created from a synthesis of DMSP OLS nighttime visible data and GOES infrared data. Cities are shown in yellow; low clouds in pink/red; high clouds in cyan; and snow cover in white. This type of product can only be simulated today from multiple instruments. In the VIIRS era, this nighttime imagery product will be generated routinely from a single instrument.